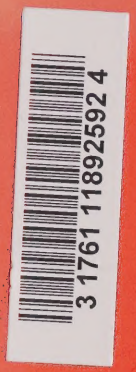

The North Pickering Project

North Pickering Commuting Analyses

(A Background Paper)

B. G. Hutchinson, P.Eng.
Waterloo, Ontario

April, 1974
Revised March, 1975

Ministry of Housing
Ontario

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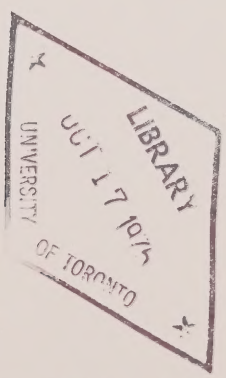

The analyses described in this report were conducted by John Freeman

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SUMMARY

A concern in the planning of the North Pickering Community is the probable extent of commuting to and from the proposed community. There are a number of communities on the fringe of Metropolitan Toronto which currently experience high levels of work trip commuting. The principal factor influencing the commuting patterns to and from a community is the balance between housing and jobs in that community.

The objective of the study described in this report was to examine the probable impact of different mixes of housing types within the North Pickering Community on commuting patterns to and from the community. Current commuting patterns in the Toronto region suggest that a housing policy within North Pickering which emphasized low-density single family housing would tend to stimulate the development of long distance commuting patterns to job opportunities within Metropolitan Toronto. On the other hand a housing policty which emphasized higher density multiple-family housing would tend to discourage these longer distance commuting trips.

A number of development scenarios have been postulated for the North Pickering Community for the 1986 and 2001 planning horizons. Included in these scenarios were 1986 population targets of 25,000 and 60,000 along with a 2001 population target of 90,000. As well, housing density mixes ranging from seventy percent low density housing opportunities through to seventy percent high density housing opportunities were analyzed. These scenarios were developed in February, 1974 and do differ marginally from the characteristics now planned for the community. However, the differences are not great enough to invalidate the conclusions developed on the basis of the original analyses.

Each of the development scenarios was analyzed using a land use-transport computer model. The residential location decisions of employees were analyzed in terms of three income groups.

If the new Toronto International Airport and the North Pickering Community are considered as a unit then for the 1986 planning horizon the degree of self-containment of North Pickering varied from about 68 percent to 80 percent. The larger community size combined with greater emphasis on high density housing yielded higher degrees of self-containment. Under these conditions the community becomes a more attractive place to live particularly for the service employees working at the new Toronto International Airport.

Similar results were obtained for conditions postulated for 2001. These analyses did indicate, however, that the removal of employment opportunities at the new airport would decrease the degree of self-containment of North Pickering from 73 percent to 61 percent.

The analyses described in this report suggest that the housing policies being proposed for the North Pickering Community will not encourage the development of long distance commuting patterns to and from the community of the type that now exist in the City of Mississauga. Housing policies which emphasize medium and high density housing opportunities are more compatible with the housing demands likely to be created by the employment types expected to locate in North Pickering and at the airport.

1.0 INTRODUCTION

This report describes one of a group of studies directed towards an analysis of the probable regional setting of the North Pickering community. It is concerned with an analysis of the probable commuting patterns to and from the proposed North Pickering community. The specific objective set for the study described in this report was:

To examine the probable demand for residential location within the North Pickering community from employment opportunities located outside the community and through this to develop a more detailed understanding of the probable role of commuting in the development of the North Pickering community.

The principal factor influencing the commuting patterns to and from a community located on the fringe of a major metropolitan area is the balance between housing and job opportunities at particular locations throughout the area. For example, the City of Mississauga on the western fringe of Metropolitan Toronto provides a current example of a community experiencing high levels of commuting trips. The housing opportunities that exist currently in Mississauga tend to cater to white collar workers many of whom work in central Toronto and other parts of the Toronto region. Many of the current employment opportunities that exist in Mississauga are of the blue collar type attracting employees who live outside of Mississauga. This imbalance in housing and employment opportunities creates a demand for additional regional-level transport facilities.

A principal notion of the Toronto-Centred Region plan is the development of a set of a relatively self-contained communities. The emphasis of the analyses described in this report was to examine the probable impact of different mixes of housing types within the North Pickering community on commuting patterns to the community. A housing policy in North Pickering which emphasized low density single-family housing would tend to stimulate the development of long distance commuting patterns to job opportunities within Metropolitan Toronto. In contrast, a housing policy which emphasized higher density multiple-family housing would tend to discourage these longer distance commuting trips.

2.0 THE ANALYSIS APPROACH

Figure 1 shows the sequence of activities followed in analyzing the commuting patterns with respect to the North Pickering community. The analyses were performed for the 1986 and 2001 horizon years. The principal inputs to the analysis process illustrated in Figure 1 are the population and employment allocations prepared by the COLUC Task force and the expected transport system properties for the two horizon years.

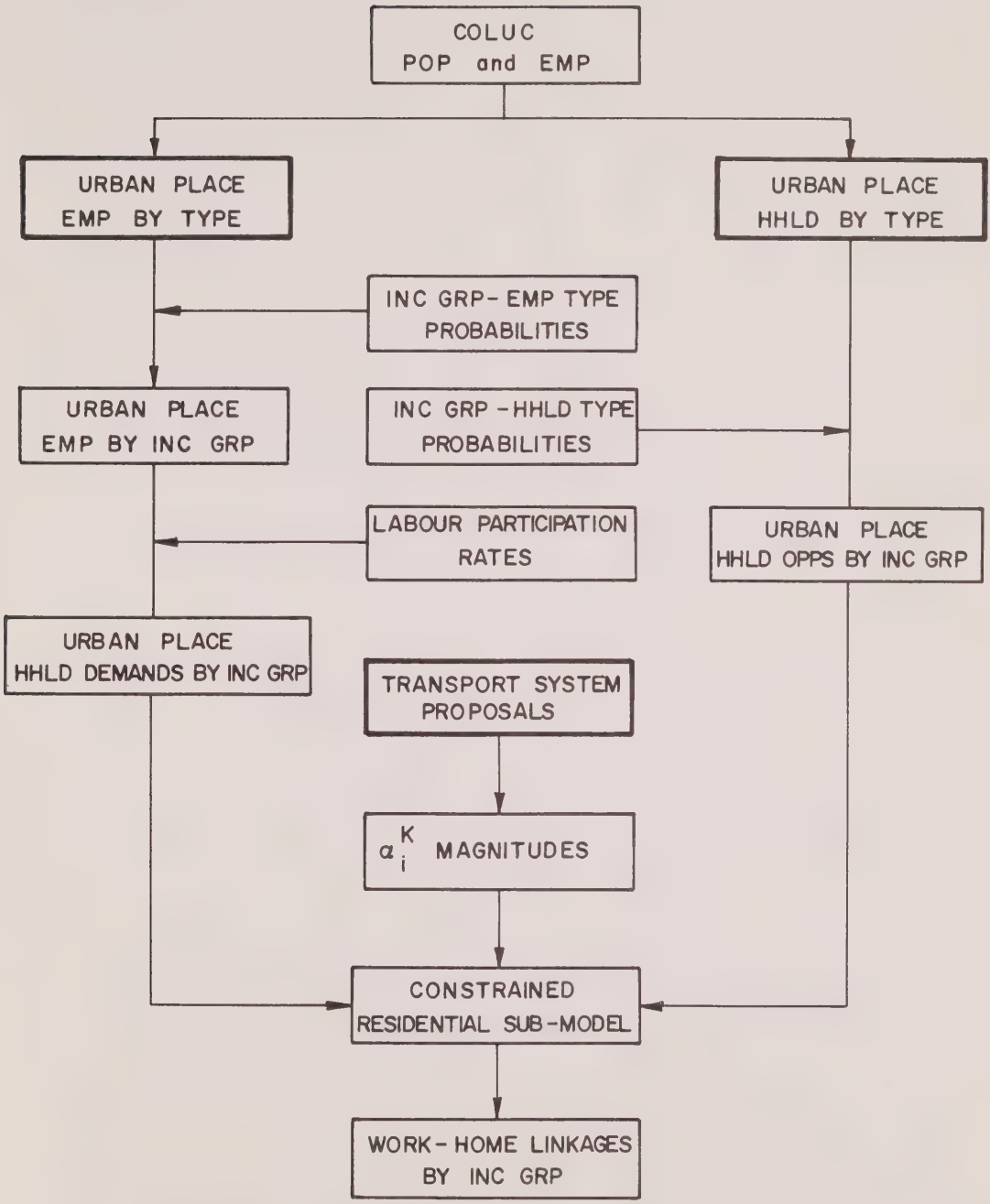


FIGURE I - ACTIVITIES IN NORTH PICKERING COMMUTER DEMAND MODEL

These three regional planning inputs are outlined by the heavy lines in Figure 1. The term urban place which is used in Figure 1 refers to the urban communities throughout the COLUC Region identified by the Task Force. The locations and boundaries of the urban places are illustrated in Appendix C.

The importance of conducting analyses of this type with respect to a number of separate socio-economic groups has been mentioned previously. The interactions between housing and employment opportunities have been analyzed with respect to three separate income groups which have been identified simply as high, medium and low income groups.

The left hand side of Figure 1 demonstrates that the employment opportunities by employment sector are converted first into employment opportunities by income group using an income group-employment sector type probability matrix. This matrix shows the probabilities of employees in each income group being represented in each of the manufacturing, service and retail sectors. The nature of this probability matrix is illustrated in Appendix A. Figure 1 illustrates that these employment opportunities by income group are then converted into household demands by income group at each urban place which must find residential locations throughout the region.

The activities shown on the right hand side of Figure 1 deal with the calculation of the spatial distribution of household opportunities by income group. The expected household opportunities by broad density class are converted into a supply of housing opportunities for each income group at each urban place. This conversion takes place through the use of an income group-household density class probability matrix. This matrix shows the probabilities of employees in each income group living in housing within each density class. The nature of the probability matrix used is illustrated in Appendix A.

The lower part of Figure 1 illustrates that the demands for household opportunities by income group at each workplace location are then allocated to compatible housing opportunities using a constrained residential sub-model of a Lowry-type land use model. The structure of this land use model is described briefly in Appendix A. Figure 1 illustrates that the allocation of housing demand to housing supply opportunities is a function of the transport system properties expected in the region in the particular horizon year.

Appendix B describes briefly the nature of the computer program used in the analyses decribed in this report. Appendix B describes as well the sources of data used in the analyses. The computer program has the capability of allocating household demands to housing opportunities in such a way that the demand allocated to any one urban place does not exceed the opportunities available at that urban place. The program calculates as well the work to home origin and destination

matrix for each income group. These travel demand matrices were input directly into an all-or-nothing traffic assignment computer program which calculated the work trip volumes on the links of a skeleton transport network. This network is shown in Appendix C.

3.0 NORTH PICKERING HOUSING SCENARIOS

Nineteen separate scenarios for North Pickering were analyzed and the characteristics of each of these scenarios are summarized in Table 1. These scenarios were developed for the 1986 and 2001 planning horizons as indicated in Table 1. This table shows that for 1986 population targets of 25,000 and 60,000 were assumed for the North Pickering community. This table also shows the total number of housing opportunities assumed for the community along with the split of these housing opportunities between low and high densities. Total employment and the breakdown of this employment between the various sectors is also provided along with the employment at NTIA. Target populations of 90,000 and 105,000 were assumed for the 2001 planning horizon.

The scenarios identified in Table 1 were developed in February, 1974 before the characteristics of the North Pickering community had been finalized. The characteristics now planned for the community are:

target population = 75,000
housing opportunities (in terms of population)
low density = 25,000
medium density = 33,200
high density = 16,400
labour force = 31,500
employment = 31,500
50% of resident labour force also works in the community

While the scenarios developed in February, 1974 do not cover exactly the characteristics now planned for the community they are adequate for estimating the probable impacts on commuting of different housing policies at North Pickering.

The purpose of each of the analyses listed in Table 1 is described below.

Runs 1,2: to explore how regional travel characteristics might change when household location decisions are constrained to available housing opportunities for 1986

Runs 3,4: same as 1,2 except for 2001 horizon year

Runs 5,6: to explore how regional travel patterns might change if the population of North Pickering in 1986 is increased from 25,000 to 60,000

TABLE 1 - CHARACTERISTICS OF REGIONAL SCENARIOS TESTED

		RUN NO.	YEAR	TOTAL POP.	HOUSING OPPORTUNITIES			EMPLOYMENT				NTIA
					TOTAL	LOW D.	HIGH D.	TOTAL	MAN.	SERVICE	RETAIL	
AGG.	UNCONST.	1*	1986	25,000	8,000			10,000				20,000
	CONST.	2*	1986	25,000	8,000			10,000				20,000
	UNCONST.	3*	2001	105,000	33,400			46,000				56,000
	CONST.	4*	2001	105,000	33,400			46,000				56,000
DISAGGREGATED CONSTRAINED		5	1986	25,000	8,000	4,000	4,000	10,000	3,000	5,500	1,500	20,000
		6	1986	60,000	19,000	9,500	9,500	19,000	4,000	10,000	5,000	20,000
		7	2001	105,000	33,400	16,700	16,700	40,000	14,000	18,000	8,000	56,000
		8	2001	105,000	33,400	16,700	16,700	46,000	14,000	25,000	7,000	0
		9	2001	90,000	27,000	13,500	13,500	34,500	12,000	15,500	7,000	56,000
		10	1986	25,000	8,900	2,600	6,100	10,000	3,000	5,500	1,500	20,000
		11	1986	25,000	7,300	5,100	2,200	10,000	3,000	5,500	1,500	20,000
		12	2001	105,000	36,900	11,100	25,800	40,000	14,000	18,000	8,000	56,000
		13	2001	105,000	30,400	21,300	9,100	40,000	14,000	18,000	8,000	56,000
		14	1986	60,000	21,000	6,300	14,700	19,000	4,000	10,000	5,000	20,000
		15	1986	60,000	17,400	12,200	5,200	19,000	4,000	10,000	5,000	20,000

* Runs 16-19 are similar to runs 1-4 respectively except different travel time factors are used

Runs 7,9: same as 5,6 except for 2001 horizon year populations of 90,000 and 105,000

Runs 5, 10,11 : to explore how the travel demands to and from North Pickering change when housing opportunities by economic group are varied from emphasis on low density to emphasis on higher density

Runs 6, 14,15 : same as 5,10,11 except that population of North Pickering is increased from 25,000 to 60,000

Runs 7, 12,13 : same as 5,10,11 except for 2001 horizon year with North Pickering total population of 105,000

Runs 7,8: to explore the impact of decreasing the employment at the New Toronto International Airport (NTIA) from 56,000 to 0 in 2001

Runs 1,16: to explore the impact on the degree of self-containment of North Pickering of a change in the travel time factor parameter of the residential sub-model

Runs 2,17: same as 1,16

Runs 3,18: same as 1,16

Runs 4,19: same as 1,16

4.0 NORTH PICKERING COMMUTING PATTERNS

Table 2 provides a summary of the commuting trips to residences in North Pickering and from employment within North Pickering for each of the scenarios tested. The information contained in this table may be illustrated by explaining the entries for Run 1 in some detail.

The model suggests that there will be 6,741 trips to residential locations in North Pickering. Of these 6,471 trips, 846 (13%) will be from employment opportunities within North Pickering; 469 (7%) will be from employment within the Toronto zones; 1,011 (15%) will be from employment opportunities in the eastern zones such as Pickering, Ajax and Oshawa; 3,871 (60%) will be from employment at the NTIA; the remaining 274 trips will be from other parts of the COLUC region. Of the 10,000 trips from jobs located within North Pickering, 5,881 (59%) will be residences within the Toronto zones; 2,271 (23%) will be to residences within the eastern zones; it has already been mentioned that 13% of the trips are to residences within North Pickering.

Table 3 shows the commuting characteristics from the NTIA along with the percent of inter-urban place trip making for the region as a whole.

TABLE 2 - NP AND NTIA COMMUTER STATISTICS

RUN #			TO NORTH PICKERING			FROM NORTH PICKERING		
	TOTAL DAILY TRIPS	INTRAZONAL	FROM TORONTO (18-33)	FROM EAST (13,14,16,17)	FROM NTIA (38)	TOTAL DAILY TRIPS	TO TORONTO (18-33)	TO EAST (13,15,16,17)
1 86	6,471	846 13%	469 7%	1,011 15%	3,871 60%	10,000	5,881 59%	2,271 23%
2 86	9,472	1,204 13%	880 9%	1,693 18%	5,207 55%	10,000	5,033 50%	2,284 23%
3 2001	45,486	11,094 24.4%	2,358 5.2%	4,537 10%	26,505 58.2%	46,000	21,068 45.8%	10,728 23.3%
4 2001	41,053	9,578 23.3%	2,218 5%	4,667 11.4%	23,882 58.2%	46,000	20,117 43.8%	9,679 21%
5 86	8,960	1,487 16.6%	539 6%	1,008 12.3%	5,610 63%	10,000	4,747 47.5%	2,149 22%
6 86	20,828	5,966 28.6%	1,409 6.8%	2,543 12%	10,018 48.5%	19,000	8,272 38%	3,366 17.7%
7 2001	39,612	10,003 25%	1,396 4%	3,103 8%	24,608 62%	40,000	15,988 40%	7,991 20%
8 2001	36,660	22,536 61%	4,146 11%	8,572 23%	0	46,000	11,693 25%	6,742 14.6%
9 2001	32,119	7,077 22%	1,081 3%	2,424 8%	21,147 66%	34,500	14,653 42%	9,141 26%
10 86	9,627	1,628 17%	575 6%	1,073 11%	6,011 62%	10,000	4,652 46.5%	2,151 21.5%
11 86	8,268	1,348 16%	493 6%	942 11%	5,183 63%	10,000	4,839 48.5%	2,207 22%
12 2001	43,195	11,142 26%	1,540 4%	3,478 8%	26,480 61%	40,000	15,259 38%	7,771 19%
13 2001	36,442	9,026 25%	1,294 4%	2,824 8%	22,840 63%	40,000	16,623 42%	8,169 20%
14 86	22,633	6,580 29%	1,569 7%	2,811 12.5%	10,777 47.6%	19,000	6,845 36%	3,235 17%

TABLE 2 (Continued)

15	19,340	5,450	1,304	2,359	9,490	19,000	7,576	3,476
86		28%	7%	12%	49%		40%	18.3%
16	7,984	432	4,458	1,178	1,537	10,000	6,866	1,842
86		5%	55.8%	14.7%	19.2%		69%	18.4%
17	10,708	547	5,964	1,763	1,928	10,000	6,880	1,549
86		5%	55.7%	16.5%	18%		69%	15.5%
18	43,002	6,244	16,976	5,253	13,182	46,000	26,048	9,724
2001		14.5%	39.5%	12.2%	30.6%		56.6%	21.1%
19	43,583	6,183	16,348	6,678	13,069	46,000	27,723	7,165
2001		14.2%	37.5%	15.3%	30%		60%	15.5%

TABLE 3 - N.T.I.A. COMMUTER STATISTICS AND REGIONAL CHARACTERISTICS

	FROM N.T.I.A.				REGIONAL	
RUN #	TOTAL DAILY TRIPS	TO TORONTO	TO EAST	TO N.P.	MTL (MINUTES)	INTERZONAL* TRIPS & % OF TOTAL
1	20,000	10,775 54%	4,002 20%	3,841 19%	27.14	105 62%
2	20,000	8,462 42%	3,842 19%	5,207 26%	27.96	118 70%
3	56,000	17,802 31.7%	8,065 16.2%	26,505 47.3%	28.26	128 58%
4	56,000	17,739 31.6%	8,534 15.2%	23,882 42.6%	29.04	122 56%
5	20,000	7,818 39%	3,805 19%	5,610 28%	28.13	848 50%
6	20,000	5,354 26.8%	2,638 13.2%	10,108 50.5%	28.04	857 50%
7	56,000	16,150 29%	8,672 15%	24,608 44%	28.12	949 43%
8	0	-	-	-	28.17	899 42%
9	56,000	17,649 32%	9,592 17%	21,147 38%	28.15	944 43%
10	20,000	7,573 38%	3,708 18.5%	6,011 30%	28.12	847 50%
11	20,000	8,072 40%	3,906 19.5%	5,183 26%	28.13	848 50%
12	56,000	15,072 27%	8,252 15%	26,480 47%	28.10	959 43%
13	56,000	17,165 31%	9,066 16%	22,840 41%	28.13	949 43%
14	20,000	4,956 24.8%	2,475 12.4%	10,777 54%	28.03	857 50%
15	20,000	5,725 28.6%	2,786 14%	9,490 47.5%	28.04	857 50%
16	20,000	13,251 66.3%	3,493 17.3%	1,536 7.7%	32.62	1,374 81%
17	20,000	13,136 66%	2,961 15%	1,928 4.6%	32.87	1,440 85%
18	56,000	28,052 50%	10,473 18.7%	13,182 23.5%	32.73	1,742 79%
19	56,000	29,890 53.4%	7,726 13.8%	13,069 23.3%	33.08	1,873 85%

* Trips x 1,000

Of the 20,000 trips from employment at the NTIA about 54 percent have been allocated to residential opportunities within the Toronto zones, 20 percent to opportunities in the eastern zones and 19 percent to opportunities within North Pickering. This table shows that about 62 percent of all trip making within the COLUC region is likely to be inter-urban place and that this percentage is likely to increase to 70 percent for constrained residential location decisions.

Detailed comments on each of the analyses are contained in Appendix D.

The following comments summarize the principal observations on the alternative scenarios described in detail in Appendix D.

1) When the housing allocations are unconstrained to the household supply in each zone the average trip time tends to be shorter than in the constrained case. Zones of concentrated employment tend to be over-allocated with households. At the North Pickering scale the degree of self-containment of the community does not change significantly between the unconstrained and constrained runs. The degree of self-containment is about 70 percent in both cases.

2) When the housing demand and supply are disaggregated by economic group the extent of urban place self-containment increases for the region. At the North Pickering scale the degree of self-containment increases to about 80 percent.

3) The degree of self-containment of North Pickering and communities of a similar size increases with increasing size of the urban place.

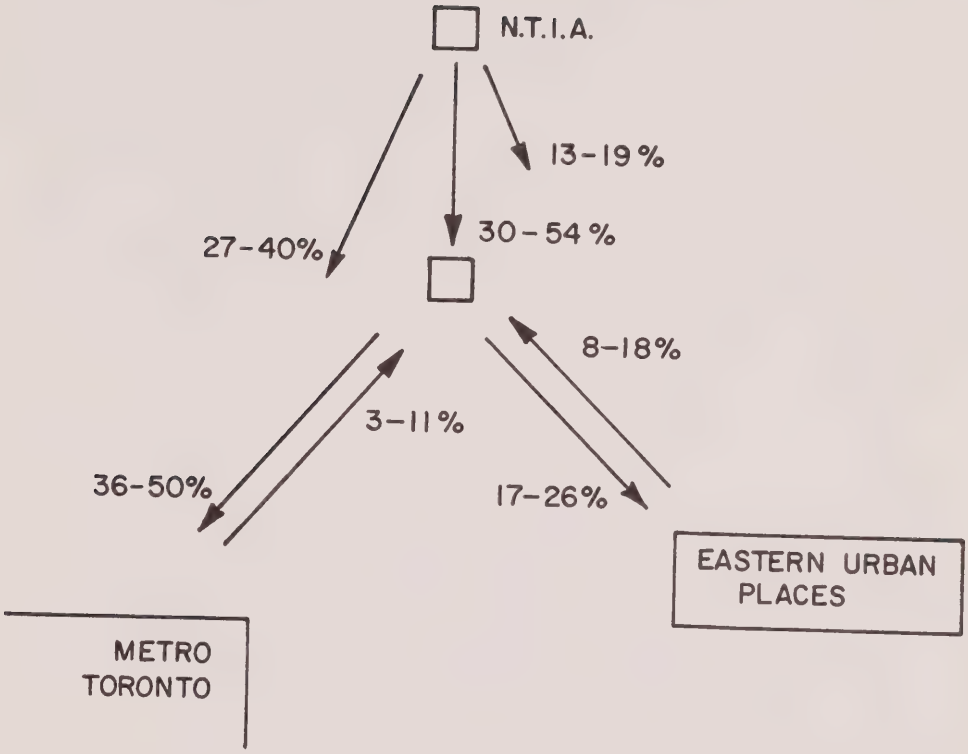
4) The impacts of changing the scale of housing supply characteristics of North Pickering are insignificant when viewed at the regional scale.

5) Lower income groups tend to make less inter-zonal trips than the higher income groups. A North Pickering housing policy which emphasizes low income housing opportunities will be more self-contained.

6) The removal of the NTIA employment decreases the degree of self-containment of North Pickering from 73 percent to 61 percent.

7) When less sensitive travel time factor parameters are assumed the degree of urban place self-containment decreases significantly.

Figure 2 illustrates the general orientation of commuting trips to and from North Pickering and the percentage ranges shown are for the scenarios described in Table 1. This diagram shows that twice as many trips originating from jobs in North Pickering and NTIA are destined to household locations in Toronto as to household locations in eastern urban places. The principal commuting linkages to jobs within North Pickering are from the eastern zones as opposed to Toronto. The diagram shows that 30 to 45 percent of the trips originating at NTIA locate within



PERCENTAGES SHOWN ARE PERCENTAGES OF RESIDENTIAL OPPORTUNITIES WITHIN NORTH PICKERING FOR INBOUND TRIPS OR PERCENTAGES OF EMPLOYMENT OPPORTUNITIES WITHIN NORTH PICKERING FOR OUTBOUND TRIPS

FIGURE 2 - COMMUTING PATTERNS TO AND FROM NORTH PICKERING FOR THE SET OF SCENARIOS TESTED

North Pickering.

Figure 3 summarizes the extremes of the degrees of self-containment at the regional and North Pickering scales. The upper line of each bar represents the 2001 planning horizon information while the lower line the information for 1986. The left hand group is for the region as a whole. This diagram shows that the degree of self-containment increases from 29 percent for the aggregated analysis to about 50 percent for the disaggregated analysis for 1986. When the less sensitive travel time factor parameters are used the degree of self-containment decreases to about 15 percent. The other three groups of information show the degree of self-containment for North Pickering. The left hand bar of each group illustrates the state when the NTIA is considered to be a zone external to the North Pickering community. The right hand bar illustrates the state when the NTIA is considered simply as an employment zone within the North Pickering community.

5.0 CORRIDOR TRAFFIC VOLUMES

The skeletal corridor-level traffic network used for the study is described in Appendix C. The portion of this network in the vicinity of the North Pickering community is illustrated in Figure 4. The daily volume of work to home trips for run numbers 1,5,10 and 11 on the network links around North Pickering are summarized in Table 4. The link volumes for run numbers 3,7,12 and 13 are presented in Table 5 while Table 6 summarizes the link volumes for run numbers 8, 16 and 18.

As would be expected the trip volumes on these links will vary with the degree of self-containment achieved for the North Pickering-NTIA complex. For the scenarios tested the highest trip volumes occur on link 232-231 and these volumes are 27,300 for 1986 and 58,900 for 2001. It should be noted from the tables that the volumes on link 231-232 vary from 4,200 for run number 1 to 24,000 for run number 16. This reflects the changing number of trips destined for North Pickering from Toronto between run numbers 1 and 16, respectively. It should be remembered that the link volumes are for both car and transit trips.

REFERENCE

1. "Analysis of the Role of North Pickering Within the COLUC and Oshawa Sub-Regions: Problem Formulation", January 15, 1974.

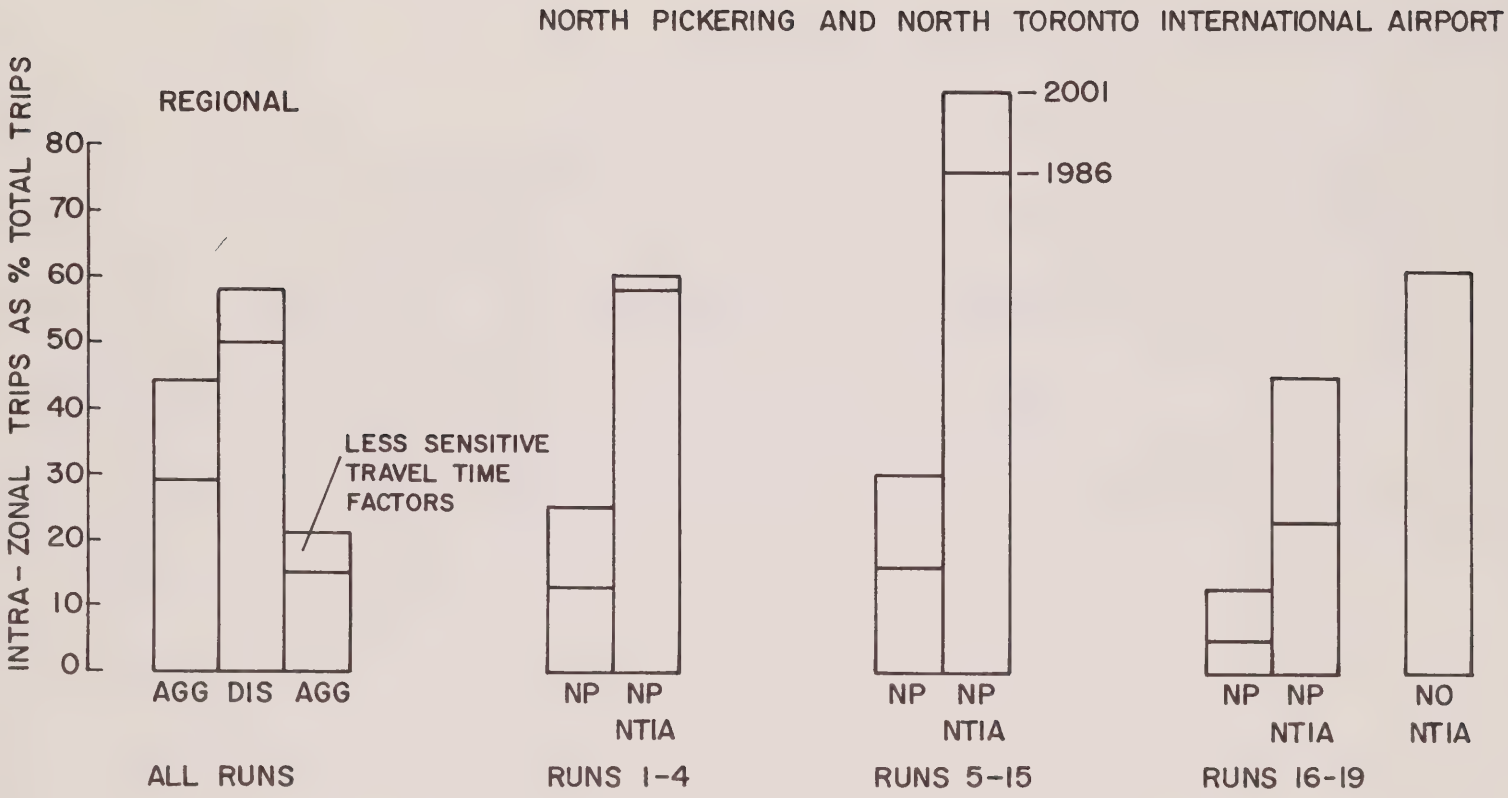


FIGURE 3 - EXTREMES OF DEGREES OF SELF - CONTAINMENT

FIGURE 4 - SKELETAL TRAFFIC NETWORK IN VICINITY OF NORTH PICKERING

TABLE 4 - WORK-HOME TRIP VOLUMES ON SELECTED LINKS

LINK		RUN NUMBER			
FROM	TO	1	5	10	11
224	232	291	303	304	301
231	232	4,229	5,446	5,485	5,411
232	224	453	613	614	613
232	231	10,949	7,544	7,407	7,696
232	233	958	382	382	382
232	240	0	0	0	0
233	232	8,207	7,381	7,189	7,586
233	234	10,559	10,341	10,097	10,595
233	239	0	0	0	0
234	233	1,183	1,017	1,077	959
239	233	19,985	19,983	19,983	19,982
240	232	0	0	0	0

TABLE 5 - WORK-HOME TRIP VOLUMES ON SELECTED LINKS

LINK		RUN NUMBER			
FROM	TO	3	7	12	13
224	232	316	426	428	423
231	232	6,159	3,908	3,975	3,852
232	224	500	463	463	462
232	231	19,046	22,994	21,873	24,028
232	233	1,263	541	543	540
232	240	0	0	0	0
233	232	14,547	17,420	16,394	18,396
233	234	26,189	24,978	23,871	25,980
233	239	0	0	0	0
234	233	4,226	3,308	3,594	3,096
239	233	55,983	55,981	55,985	55,982
240	232	0	0	0	0

TABLE 6 - WORK-HOME TRIP VOLUMES ON SELECTED LINKS

LINK		RUN NUMBER		
FROM	TO	8 (2001)	16 * (1986)	18 * (2001)
224	232	484	6,173	8,387
231	232	5,271	24,385	38,068
232	224	463	1,225	1,624
232	231	11,135	27,285	38,926
232	233	561	7,417	11,609
232	240	0	0	0
233	232	1,134	10,739	24,093
233	234	9,779	12,475	31,820
233	239	0	0	0
234	233	7,294	3,855	12,938
239	233	0	19,983	55,983
240	232	0	0	0

APPENDIX A - DETAILED DESCRIPTION OF THE RESIDENTIAL SUB-MODEL

Figure 1 indicated that the demand for households by income group is estimated from a knowledge of the employment by type. The estimation of demand proceeds by the following means.

$$[e^k] = [e^{kc}][e^c] \qquad (1)$$

where $[e^k]$ = a row vector of employment partitioned into k income groups

$[e^{kc}]$ = a k x c matrix of probabilities that person type k will be employed in industry category c

$[e^c]$ = a row vector of employment partitioned into c industry categories

The operation described in Eq. (1) is in fact accomplished in two steps in the computer program. Employment by category is first converted into occupation by type and occupation by type is then transformed into employment by income group.

Table A.1 shows the occupation type-employment category probability matrix. This table shows, for example, that manufacturing employment contains about 11 percent professional, 19 percent clerical and 70 percent labour occupations. A one zone example of the conversion of employment by category into employment by occupation type is provided in Table A.1.

Table A.2 illustrates the employment by income group-occupation type probability matrix. This table illustrates that the clerical type occupations contain about 52 percent low income employees, 41 percent medium income and 7 percent high income employees. A one zone example is shown in Table A.2 to illustrate the use of the probability matrix. The vector of employment by occupation type derived in Table A.1 is converted into employment by income group.

The next phase of the household demand analysis is to aggregate the employees by income group into household heads by household income group. For example, working wives and children do not demand independent households. Census data indicate that the majority of working wives and children are associated with household income groups in various proportions. Table A.3 shows the household income group-employee income group association matrix. The entries show the probability of an employee in the income group listed at the top of the column being associated with the household income group named in the row. For example, low income employees have a 20 percent probability of being associated with a medium income household and only a 10 percent probability of being associated with a high income household. An example is provided in Table A.3 in which the employees by income group are converted into employees by household income group.

TABLE A.1 - OCCUPATION TYPE-EMPLOYMENT CATEGORY PROBABILITY MATRIX

OCCUPATION CATEGORY	INDUSTRY CATEGORY		
	MANUF.	SERVICE	RETAIL
PROF.	0.110	0.250	0.130
CLERICAL	0.190	0.510	0.560
LABOUR	0.700	0.2400	0.310

EXAMPLE FOR 1 ZONE

manuf. exp. = 20,000 service empl. = 50,000 retail emp. = 10,000

$$\begin{bmatrix} 20{,}000 \\ 50{,}000 \\ 10{,}000 \end{bmatrix} \begin{bmatrix} .110 & .250 & .130 \\ .190 & .510 & .560 \\ .700 & .240 & .310 \end{bmatrix} = \begin{bmatrix} 16{,}000 \\ 34{,}900 \\ 29{,}100 \end{bmatrix}$$

16,000 professional employees
34,900 clerical employees
29,100 labour employees

16,000 = 20,000 x 0.110 + 50,000 x 0.250 + 10,000 x 0.130

i.e., 80,000 jobs in zone have been converted into 80,000 employees by occupation category.

TABLE A.2 - EMPLOYEE INCOME GROUP - OCCUPATION TYPE PROBABILITY MATRIX

EMP. INC. GROUP	OCCUPATION TYPE		
	PROF.	CLERICAL	LABOUR
LOW	0.080	0.520	0.290
MEDIUM	0.470	0.410	0.640
HIGH	0.450	0.070	0.070

EXAMPLE FOR 1 ZONE

$$\begin{bmatrix} 16{,}000 \\ 34{,}900 \\ 29{,}100 \end{bmatrix} \quad \begin{bmatrix} .080 & .520 & .290 \\ .470 & .410 & .640 \\ .450 & .070 & .070 \end{bmatrix} \quad = \quad \begin{bmatrix} 27{,}867 \\ 40{,}453 \\ 11{,}680 \end{bmatrix}$$

27,867 low income employees
40,453 medium income employees
11,680 high income employees

27,867 = 16,000 x .080 + 34,900 x .520 + 29,100 x .290

i.e., 80,000 employees by occupation type have been converted into 80,000 employees by income group.

TABLE A.3 - EMPLOYEES BY HOUSEHOLD INCOME GROUP - EMPLOYEES BY INCOME GROUP

HOUSEHOLD INC. GROUP	EMPLOYEE INCOME GROUP		
	LOW	MEDIUM	HIGH
LOW	0.70		
MEDIUM	0.20	0.80	
HIGH	0.10	0.20	1.00

EXAMPLE FOR 1 ZONE

$$\begin{bmatrix} 27{,}867 \\ 40{,}453 \\ 11{,}680 \end{bmatrix} \begin{bmatrix} .70 & & \\ .20 & .80 & \\ .10 & .20 & 1.00 \end{bmatrix} = \begin{bmatrix} 19{,}507 \\ 37{,}936 \\ 22{,}557 \end{bmatrix}$$

19,507 low income households
37,936 medium income households
22,557 high income households

$37{,}936 = 27{,}867 \times .20 + 40{,}453 \times .80$

i.e., 80,000 employees by income group have been converted into 80,000 household demands by income group

Employees by the various income groups tend to come from households of different sizes. For example, because of unemployment there is slightly less than 1.0 employee per household for the low income households. In contrast, the high income households have about 1.90 employees per household. The labour participation rates used in this project are shown in Table A.4. A simple example is provided in Table A.4 which illustrates the manner in which employees by household income group are converted into the demand for households by income group.

The supply of households for each income group in each urban place may be calculated as follows:

$$[h^k] = [h^{kd}][g^d] \qquad (2)$$

where $[h^k]$ = a row vector of housing opportunities partitioned into k income groups

$[h^{kd}]$ = a k x d matrix of the probabilities that group k persons will live in housing density (or type) d

$[g^d]$ = a row vector of the number of housing opportunities g partitioned into d housing density classes

Table A.5 shows an income group-housing density matrix along with a simple example of the application of this matrix.

At this stage the demand for households in each income group created by the employment at each urban place is known as is the supply of households by income group at each urban place.

The demand for households is allocated to residential opportunities by the following equation:

$$\ell_{ij}^k = e_i^k a^k [h_j^k \exp(-\alpha_i^k d_{ij}^k) / \Sigma_j h_j^k (-\alpha_i^k d_{ij}^k) \qquad (3)$$

where ℓ_{ij}^k = the number of households in zone j used by employees in zone i in income group k

e_i^k = the employment in zone i by income group k

a^k = the labour participation rate by income group k

h_j^k = the number of housing opportunities in zone j for income group k

α_i^k = a parameter which reflects the influence that travel time has on residential location

d_{ij}^k = the travel time by the mode used by income group k in searching for a household location

TABLE A.4 - PERSONS PER EMPLOYEE
BY EMPLOYEE IN HOUSEHOLD
INCOME GROUP

EMP BY HHLD INC GROUP	PERSONS PER EMPLOYEE
LOW	0.90
MEDIUM	1.55
HIGH	1.90

EXAMPLE FOR 1 ZONE

$$[19{,}503,\ 37{,}936,\ 22{,}557] \begin{bmatrix} \frac{1}{90} & & \\ & \frac{1}{1.55} & \\ & & \frac{1}{1.90} \end{bmatrix} = [21{,}670,\ 24{,}475,\ 11{,}872]$$

TABLE A.5 - HOUSEHOLD INCOME GROUP - HOUSING DENSITY TYPE PROBABILITY MATRIX

HOUSEHOLD INC GROUP	HOUSING DENSITY TYPE	
	LOW	HIGH
LOW	0.20	0.40
MEDIUM	0.40	0.40
HIGH	0.40	0.20

EXAMPLE FOR 1 ZONE

low density housing = 20,000 high density housing = 40,000

$$\begin{bmatrix} 20{,}000 \\ 40{,}000 \end{bmatrix} \begin{bmatrix} .2 & .4 \\ .4 & .4 \\ .4 & .2 \end{bmatrix} = \begin{bmatrix} 20{,}000 \\ 24{,}000 \\ 16{,}000 \end{bmatrix}$$

low income housing opportunities

medium income housing opportunities

high income housing opportunities

APPENDIX B - DESCRIPTION OF COMPUTER PROGRAM AND DATA SOURCES

A special computer program was developed for the analyses described in this report. It represents an adaptation of the Lowry land use model used for other analyses performed in connection with the North Pickering project. Figure B.1 shows the flow of activities in this program. This diagram shows that the program consists of two parts. The first part converts the input information into household demand and supply by income group. The second part of the program allocates the household demands in either a constrained or unconstrained manner and calculates the home based work trip tables at the same time. A listing of the computer program is provided in a separate report.

The information used in the analyses described in this report have been obtained from a variety of sources and the data sources are listed below.

EMPLOYMENT (by zone and type)

- from North Pickering Group (NPG) for both 1986 and 2001
- total manufacturing and wholesale, retail and service employment supplied
- these employment figures converted to household demands by income group using the employment associated matrices (see (3))
- test ranges of employment in North Pickering (NP) and New Toronto International Airport (NTIA) from J.F. Lucey
- Tables B.1 and B.2 show the disaggregated employment data input in the model for 1986 and 2001, respectively (NOTE: the employment for NP and NTIA zones change in each run)

POPULATION (by zone)

- from NP6 for both 1986 and 2001
- test ranges of population for N.P. from NP6
- population by urban place converted to households by using the housing association matrices (see (4))
- Table B.3 shows the 1986 and 2001 populations

EMPLOYMENT MATRICES - HOUSEHOLD DEMANDS BY INCOME GROUP

- from Statistics Canada and previous Lowry model applications in Toronto area
- matrices assume an income group classification:

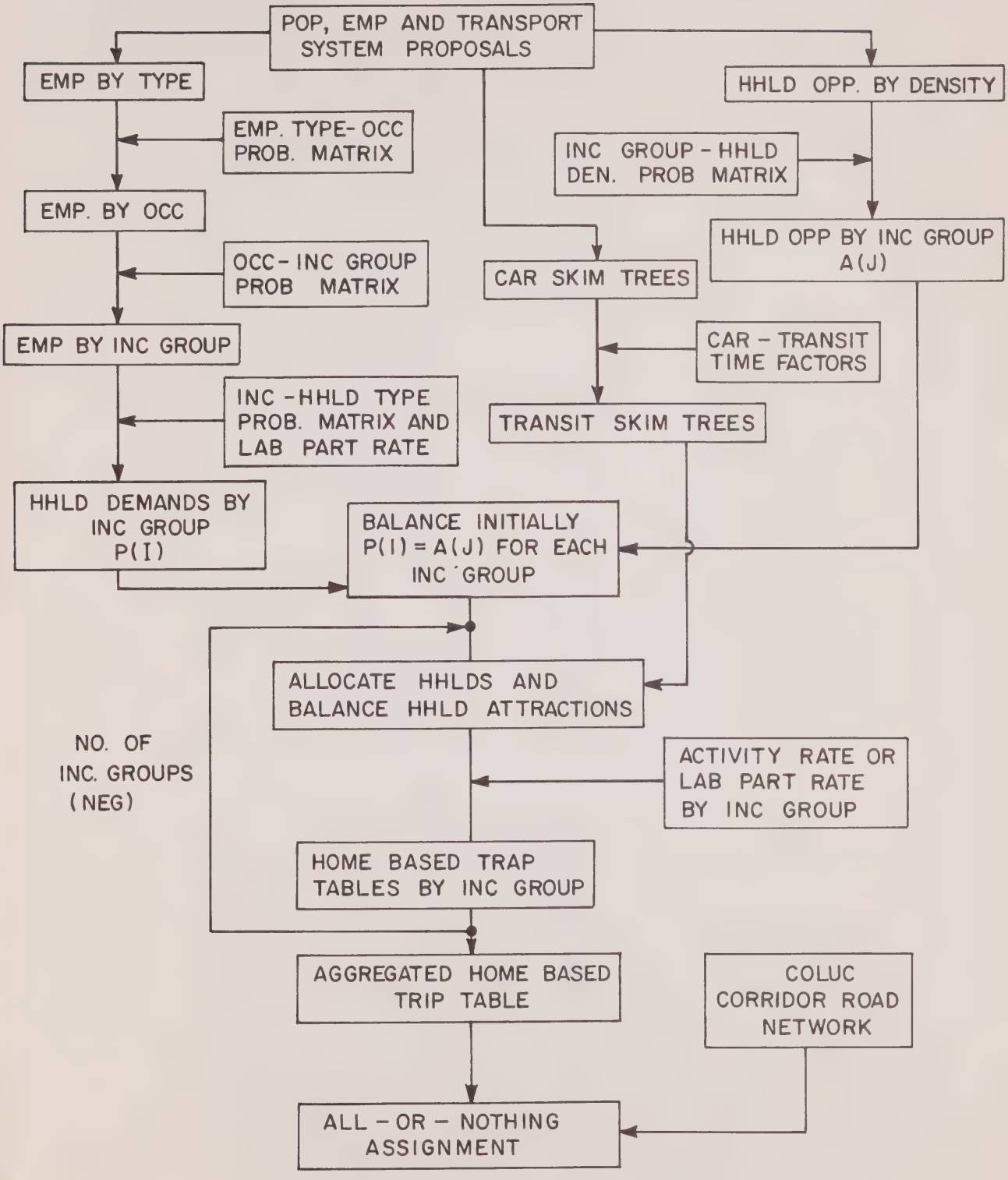


FIGURE B·1 - COMPUTER PROGRAM FLOW DIAGRAM

TABLE B.1 - EMPLOYMENT BY TYPE BY URBAN PLACE FOR 1986

ZONE #	EMPLOYMENT TYPE		
	BASIC	SERVICE	RETAIL
1	21444.	53278.	15276.
2	13200.	15125.	6189.
3	1646.	2278.	584.
4	12237.	6947.	4259.
5	19217.	9313.	3052.
6	24463.	28491.	11549.
7	7779.	4151.	2193.
8	17902.	11801.	930.
9	3786.	4531.	2162.
10	786.	670.	299.
11	6769.	4949.	2721.
12	1617.	1007.	836.
13	2579.	4889.	1937.
14	3000.	5500.	1500.
15	3742.	1934.	1429.
16	37417.	34362.	12293.
17	1470.	1253.	643.
18	65192.	225196.	57353.
19	27082.	22433.	14516.
20	59376.	27187.	22687.
21	17139.	57766.	15752.
22	24917.	18903.	7047.
23	18759.	15659.	12768.
24	32803.	12897.	8089.
25	37431.	23856.	11348.
26	43856.	7645.	5964.
27	47159.	16341.	7031.
28	3279.	17081.	12000.
29	2483.	7571.	1747.
30	44578.	27600.	16562.
31	1091.	5397.	4796.
32	2727.	7749.	2033.
33	9915.	11561.	9970.
34	3341.	8440.	1845.
35	2895.	11225.	2776.
36	4158.	2434.	1325.
37	44584.	6715.	799.
38	20000.	0.	0.
TOTAL	691819.	724126.	284260.

TABLE B.2 - EMPLOYMENT BY TYPE BY URBAN PLACE FOR 2001

ZONE #	EMPLOYMENT TYPE		
	BASIC	SERVICE	RETAIL
1	19520.	88100.	24105.
2	20639.	29571.	8242.
3	2335.	3725.	1010.
4	14045.	10911.	5604.
5	21914.	15078.	6813.
6	34590.	61580.	20755.
7	12400.	11020.	4865.
8	30020.	17185.	1615.
9	2460.	5130.	2820.
10	985.	1250.	565.
11	5000.	6340.	3695.
12	1875.	900.	1325.
13	8340.	10270.	3725.
14	14000.	18000.	8000.
15	6550.	4730.	2892.
16	44503.	71968.	21680.
17	1672.	1200.	673.
18	47334.	245877.	57100.
19	24730.	27170.	15090.
20	47105.	37310.	17030.
21	14200.	63050.	13935.
22	23460.	28280.	8420.
23	16640.	18980.	11760.
24	22240.	8605.	3745.
25	39630.	45045.	12860.
26	55120.	13940.	8540.
27	46620.	32485.	7150.
28	1820.	31735.	9990.
29	6760.	8630.	2980.
30	48670.	46850.	12900.
31	2970.	10260.	4860.
32	5110.	12770.	3550.
33	32450.	31360.	13500.
34	5845.	13075.	3360.
35	7165.	15245.	5060.
36	4655.	4865.	2715.
37	47595	11770.	810.
38	56000.	0.	0.
TOTAL	796967.	1064260.	333739.

TABLE B.3 - POPULATION BY URBAN PLACE FOR 1986 AND 2001

ZONE NO.	POPULATION (thousands) 1986	2001
1	168	179
2	124	185
3	10	15
4	80	110
5	100	155
6	240	385
7	54	120
8	20	30
9	50	65
10	8	15
11	50	95
12	18	20
13	58	110
14	20	105
15	24	50
16	195	300
17	12	15
18	161	194
19	269	267
20	274	278
21	244	256
22	129	133
23	267	271
24	71	76
25	196	214
26	77	89
27	149	161
28	168	191
29	77	105
30	223	223
31	83	95
32	64	99
33	141	259
34	56	71
35	129	171
36	43	77
37	22	24
38	0	0

Income Range	Income Group	Labour Part Rate LPR (workers/hhld)
0-4,999	Low (1)	0.9
5,000-8,999	Med (2)	1.55
9,000-∞	High (3)	1.9

(See Table B.4)

Average Labour Part Rate (LPR) = 1.35 → 1.40 (from Statistics Canada)

- matrices similar for both 1986 and 2001
- Table B.4 show the matrices employed and makeup of each group

HOUSING MATRICES

- from Statistics Canada - Ontario 1967 data - averaged
- Table A.1 shows the matrix
- similar matrix used in 1986 and 2001

HOUSING DENSITIES - HOUSEHOLD SUPPLY BY INCOME GROUP

- the proportion of high and low density households by urban place and for 1986 and 2001 from J.F. Lucey
- the high/low density percentages used summarized in Table B.4
- ranges for NP as suggested by J.F. Lucey
- the actual number of housing opportunities available in each urban place is determined by the population and housing density percentages and is calculated exogenously from the computer program in two small sub-computer programs
- this conversion assumes:
  persons/household-low density = 3.8
  persons/household-high density = 2.6
- thus if the population of NP is to be a constant then the number of households available with different household policies will differ
- Table B.5 and B6 show the resultant number of household opportunities (low/high density) by zone for 1986 and 2001 respectively

TRAVEL TIME FACTOR PARAMETERS BY DISTRICT

- assumed to be similar for all income groups for 1986 and 2001
- two sets used

TABLE B.4 - SUMMARY OF HOUSING DENSITY PROPORTIONS BY URBAN PLACE FOR 1986 AND 2001

	URBAN PLACE	1986 (%)		2001 (%)	
		LOW DENS.	HIGH DENS.	LOW DENS.	HIGH DENS.
WESTERN PLACES	1. (Hamilton)	60	40	50	50
	2. (Burlington)	70	30	60	40
	3. (Milton)	80	20	80	20
	4. (Oakville)	70	30	60	40
	5. (Brampton/Bramalea)	70	30	60	40
	6. (Mississauga)	65	35	55	45
	7. (E.M./Meadowdale)	60	40	60	40
	8. (Milton)	85	15	75	25
	34-37 (Rest of Hamilton)	60	40	50	50
NORTHERN PLACES	9. (Richmond Hill)	80	20	70	30
	10. (Woodbrige)	85	15	75	25
	11. (N.M. Fringe)	65	35	55	45
	12. (Markham/Un'le)	85	15	75	25
EASTERN PLACES	13. (Pickering)	85	15	80	20
	14. (N. Pickering)	varied between 30/70, 50/50, 70/30			
	15. (Ajax)	60	40	60	40
	16. (Oshawa/Whitby)	65	35	55	45
	17. (Bowmanville)	65	35	55	45

Metro Toronto (18-33) following procedure employed:

TPOP01 - zone population 2001

TPOP86 - zone population 1986

NL01 - # of low density units 2001 - initial (NLH01 - used as input)

NH01 - # of high density units 2001 - initial (NHH01 - used as input)

NL86 - # of low density units 1986 - initial (NLH86 - used as input)

NH86 - # of high density units 1986 - initial (NHH86 - used as input)

TABLE B.4 (Continued)

```
TOTHO1 = NLO1 + NHO1
TPOPO1 = (NLO1*3.9) + (NHO1*2.6)
RATIO p = TPOPO1/PPO1
NLHO1 = NLO1/RATIOP
NHHO1 - NHOL/RATIOP
NTO1 = NLHO1 + NHHO1

NL86 = (NL71 + NLO1)/2.0
NH86 = (NH71 + NHO1)/2.0
TPOP86 = (NL86*3.9) + (NH86*2.6)
RATIO = TPOP86/PP86
NLH86 = NL86/RATIO
NHH86 = NH86/RATIO
```

TABLE B.5 - HOUSING OPPORTUNITIES BY HOUSING DENSITY CLASS BY URBAN PLACE FOR 1986

ZONE #	HOUSING DENSITY	
	LOW	HIGH
1	30500.	20400.
2	25200.	10800.
3	2200.	600.
4	16200.	7000.
5	20300.	8700.
6	46200.	24900.
7	9800.	6500.
8	4300.	1400.
9	11100.	2800.
10	1800.	300.
11	9600.	5200.
12	4100.	700.
13	11100.	5600.
14	5100.	2200.
15	4400.	2900.
16	28300.	32500.
17	2300.	1200.
18	18300.	34500.
19	34600.	52000.
20	35600.	52000.
21	36400.	39300.
22	18300.	22100.
23	34700.	50600.
24	9800.	12600.
25	25800.	36700.
26	10400.	14000.
27	18300.	29900.
28	20500.	33900.
29	9900.	14800.
30	30300.	40300.
31	11500.	14600.
32	9400.	10500.
33	20000.	24200.
34	10200.	6800.
35	23500.	15600.
36	7900.	5200.
37	4000.	2700.
38	0.	0.
TOTAL	621900.	646000.

TABLE B.6 - HOUSING OPPORTUNITIES BY HOUSING DENSITY CLASS BY URBAN PLACE FOR 2001

ZONE #	HOUSING DENSITY	
	LOW	HIGH
1	28400.	28400.
2	33600.	22400.
3	3300.	800.
4	20000.	13300.
5	28200.	18800.
6	65700.	53700.
7	21800.	14500.
8	6100.	2600.
9	13200.	5700.
10	3200.	1100.
11	16200.	13300.
12	4300.	1400.
13	24200.	6000.
14	16700.	16700.
15	9100.	6100.
16	49800.	40700.
17	2600.	2100.
18	6700.	64500.
19	32400.	54000.
20	51700.	88500.
21	43400.	33300.
22	15300.	28200.
23	38400.	46700.
24	10500.	13500.
25	32200.	34000.
26	12400.	15600.
27	17100.	36200.
28	23000.	38900.
29	11500.	23200.
30	33600.	35400.
31	14800.	14300.
32	12000.	20100.
33	39300.	40600.
34	11300.	11300.
35	27100.	27100.
36	11600.	11600.
37	3800.	3800.
38	0.	0.
	794500.	888400.

Set A - original set
Set B - from G. O'Hearne

- Table B.7 shows the parameters used

SKIM TREES

- all skim tree times derived from 1986 auto times (TARMS)
- the transit skim trees (1986) were generated from the car skim trees assuming the following factors:
  (a) transit corridor links (60 type) transit times - car times x 1.5 if tt < 40 min.
  (b) transit corridor links (60 type) transit times = car times x 1.0 if tt > 40 min.
  (c) regional bus link transit times = car times x 1.3
  (d) no direct transit link transit times - car times x 2.0
  (e) intrazonal times (diagonals) transit times = car times 0.8
  (f) Toronto and Hamilton CBD transit times = car times x 0.8
  (g) interzonal time NP, NTIA = 10 min.
    - the car trees (2001) = car trees (1986)
    - the transit times (2001) = car times (1986) factored by the above except that the no direct transit link times are factored by 1.5 (instead of 2.0)

NETWORK

- network represents major links suggested by the Ministry of Transportation and Communications of Ontario as a feasible and likely 2001 road system
- all trips, both car and transit, assigned to this network
- network (1986) = network (2001)
- all-or-nothing assignment

TABLE B.7 - TRAVEL TIME FACTOR PARAMETERS
BY DISTRICT

DISTRICT #	ALPHA	
	SET A	SET B
1	0.210	0.042
2	0.093	0.037
3	0.105	0.068
4	0.170	0.144
5	0.157	0.078
6	0.260	0.188
7	0.142	0.099
8	0.250	0.084

APPENDIX C - ZONE AND NETWORK MAPS FOR COLUC AREA

Figure C.1 shows the districts identified for the use of common travel time factor parameters and the urban places within these districts. Figure C.2 shows the urban place zones within Metropolitan Toronto while Figure C.3 shows those within Hamilton. Figure C.4 shows the corridor level skeletal transport network used for the traffic assignment analyses and the centroids of each of the urban place zones.

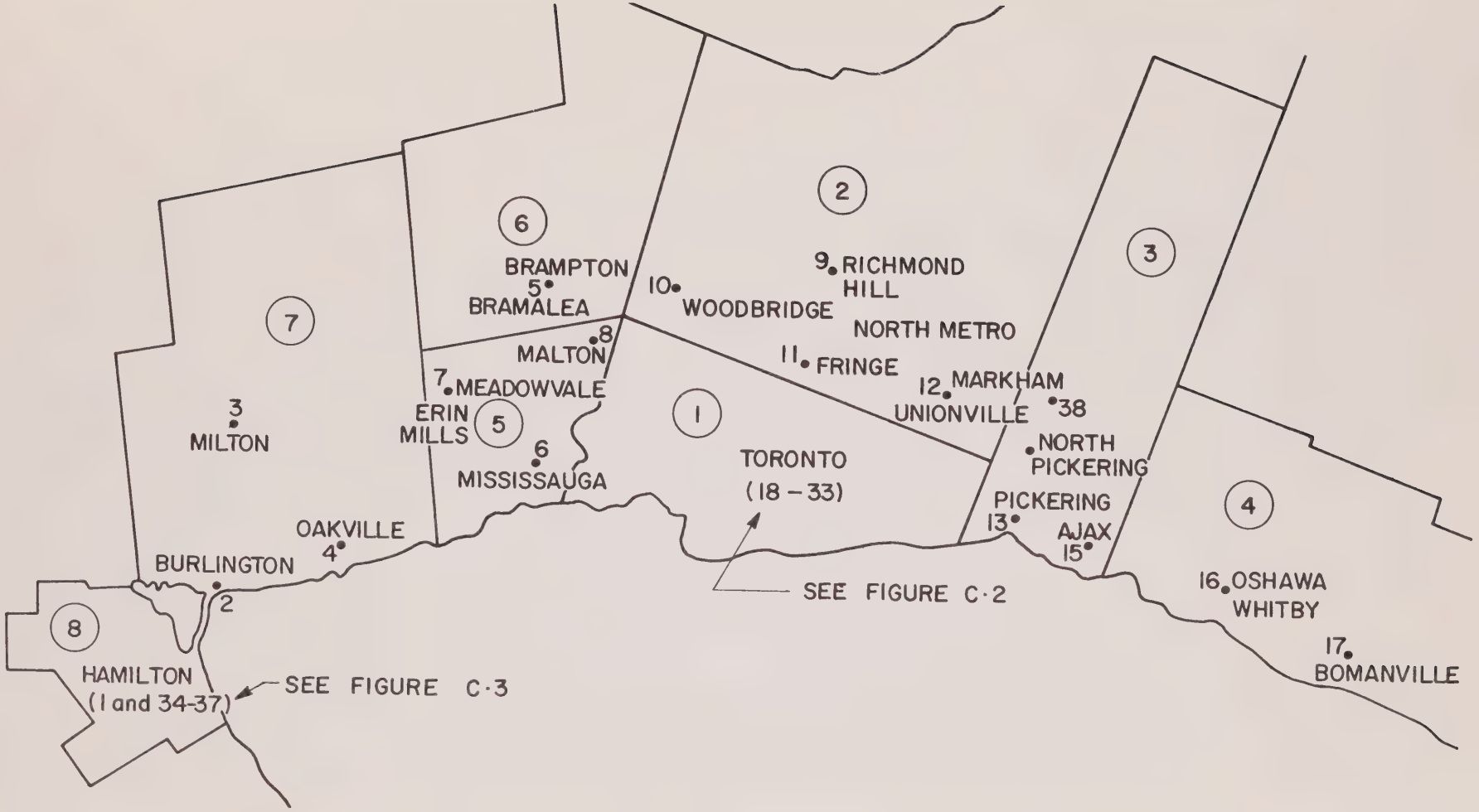


FIGURE C·1 – ANALYSIS DISTRICTS AND URBAN PLACES WITHIN COLUC AREA

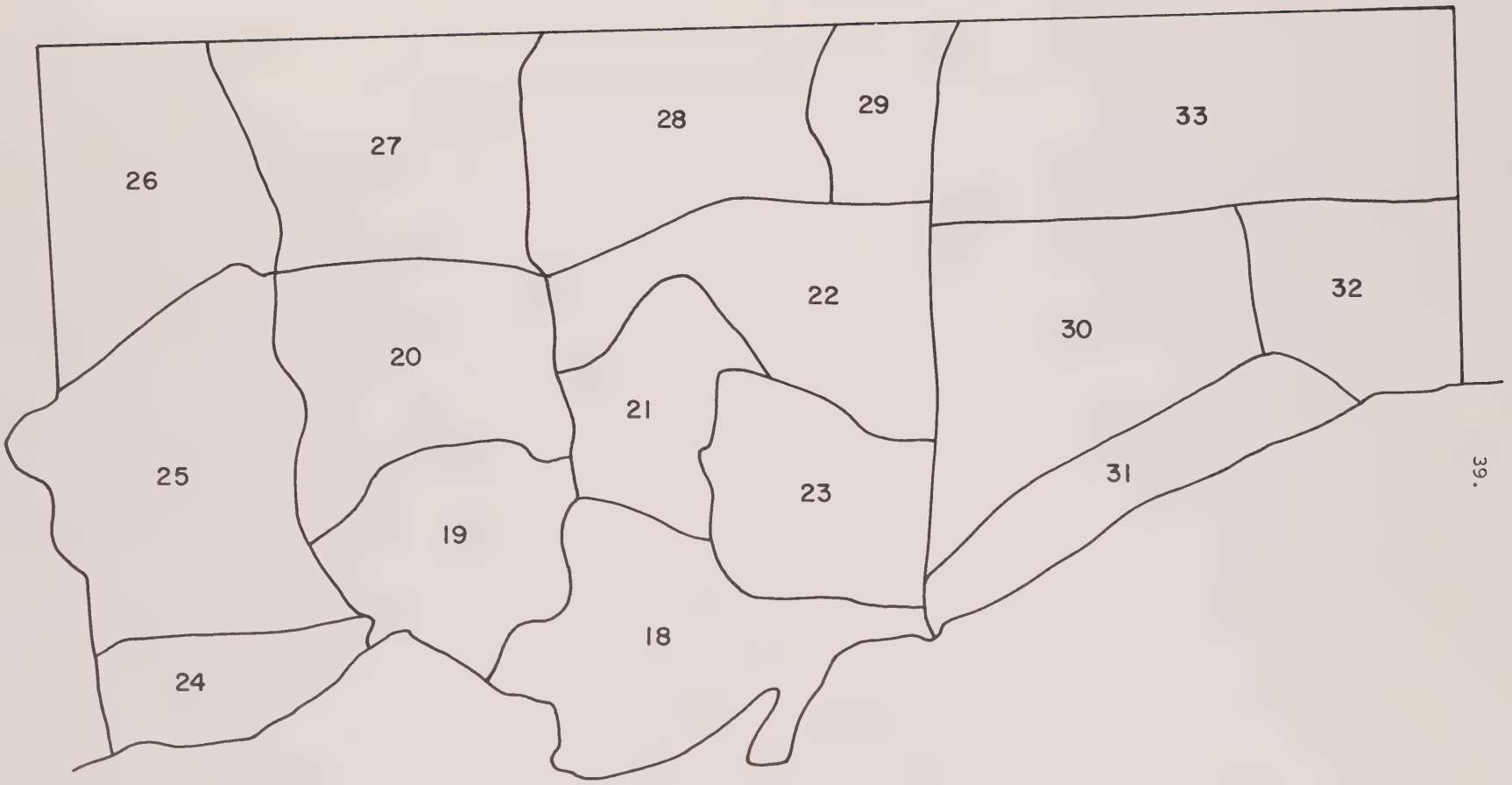


FIGURE C·2 - URBAN PLACE ZONES WITHIN METROPOLITAN TORONTO

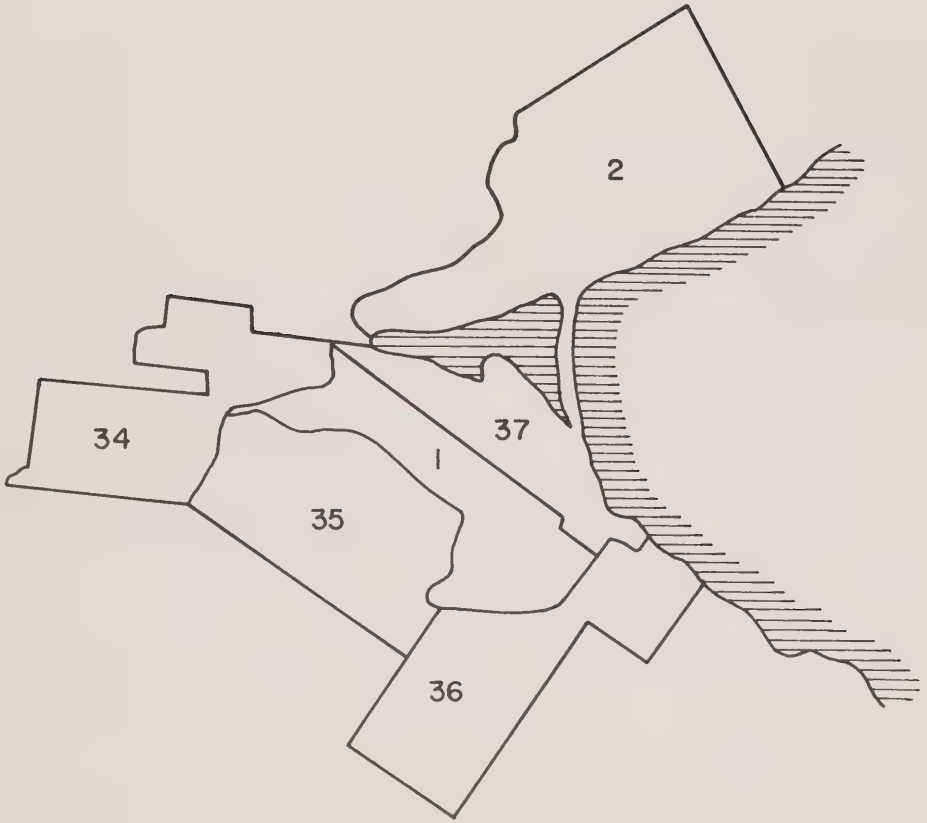


FIGURE C·3 – URBAN PLACE ZONES WITHIN HAMILTON

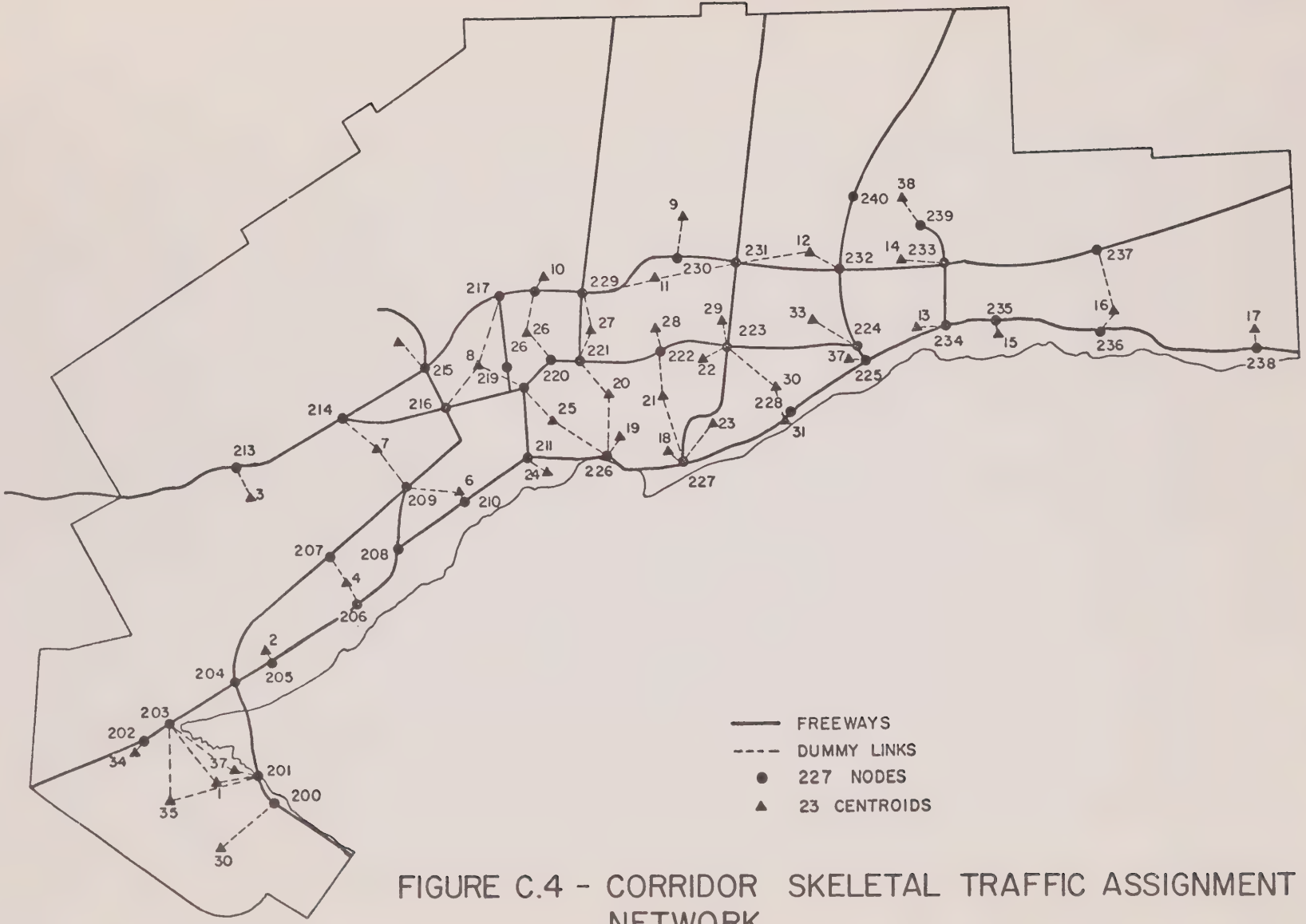


FIGURE C.4 - CORRIDOR SKELETAL TRAFFIC ASSIGNMENT NETWORK

APPENDIX D - DETAILED COMMENTS ON ALTERNATIVE SCENARIOS

The comments contained in this Appendix refer to the results of the computer analyses summarized in Tables 2 and 3.

UNCONSTRAINED AGGREGATED SCENARIOS

RUN NO. 1

General Comments

Twenty-six percent of the total regional employment opportunities are concentrated in the CBDs of Hamilton and Toronto, zones 1 and 18, respectively. These zones, in comparison to the employment, and perhaps as a consequence of it, contain few housing opportunities and they are thus severely over-allocated. That is, the housing demands in these zones are at least 50 percent greater than the housing opportunities present. Similarly, zones 20 and 21, which are fairly close to the Toronto CBD are over-allocated, since the employment/housing ratio is greater than 1 and they would attract some of the housing demands from zone 18. Other areas immediately surrounding the CBDs are not as severely over-allocated, if at all, since most have an employment/housing ratio close to 1. Oshawa-Whitby, zone 16, and Metro zones 25, 27 and 30 are also major employment areas, however, each contains enough housing to produce almost balanced allocations in the unconstrained run.

The remaining zones which may be termed residential (i.e., employment/housing < 1.0) are under-allocated. They are some distance from the employment oriented zones and do not attract sufficient demand to fill the available households.

The above conditions are a consequence of the fact that employees, when their housing search is unconstrained, will tend to locate close to their workplace. This is reflected in the number of inter-zonal trips in the region increasing when the household search is constrained, (e.g., compare run # 1 to run # 2). Also the total mean trip length (time) is slightly shorter in the unconstrained run.

Comments on NP and NTIA

Table 2 summarizes the information relevant to North Pickering, and Table 3 the information regarding North Toronto International Airport and regional characteristics.

Of the total number of people who locate in households in NP, 7 percent originate from Toronto and 15 percent from the eastern urban places.

Since the northern Metro zones (i.e., 29,33,32) are under-allocated, most of the residual household demands from the employment zones in Toronto are accommodated in these zones and few locate in NP. However, the eastern zones are not over-allocated and therefore a higher percentage of work-to-home trips originate from these zones. Only 13 percent of the trips are accommodated in NP (intra-zonal) since the northern Metro, and to a lesser extent, the eastern zones supply competitive household opportunities. Also, 60 percent of the NP households filled are occupied by NTIA employees and they tend to displace the NP employees. If NP and NTIA are considered to form one zone (the inter-zonal time is equal to the intra-zonal times) then 73 percent of the trips are completed within the zone. This represents a very high degree of self-containment.

Of the work-to-home trips originating in NP and NTIA twice as many are directed towards residential locations in Toronto as compared to the eastern zones. This is the reverse of the trips destined to NP because of the relative availability of households in each. Only 19 percent of the NTIA employees locate in NP even though it is adjacent, since the larger communities (i.e., north Metro and Oshawa) are inherently more attractive. This also explains why NP is under-allocated even though the employment in NP and NTIA is substantially larger than the number of housing opportunities.

Run No. 3

General Comments

The regional zonal housing allocations resulting in 2001 may be explained generally by examining the change in employment and housing opportunities between 1986 and 2001. For example, both the CBD zones of Toronto and Hamilton were severely over-allocated in 1986. The slightly smaller over-allocation in zone 18 in 2001 is a result of the increase in housing opportunities which is larger than the employment increase (51,000 to 72,000 and 347,000 to 350,000, respectively). In contrast, in Hamilton, the employment increases from 90,000 to 132,000 and the housing opportunities from 50,000 to 57,000 and the CBD is more severely over-allocated. The residential zones are still underallocated although generally not to the same degree as in 1986.

The total mean trip length (time) in 1986 is 27.14 minutes and in 2001 is 28.26 minutes. The increase is due to the larger travel times used in the 2001 analysis, i.e., the 2001 times are all 10 percent longer than the 1986 times. This leads to a decrease in the percentage of inter-zonal to total trips from approximately 62 to 58 percent and therefore, in general, a greater degree of containment.

Comments on NP and NTIA

The major change in the housing location decisions between 1986 and 2001 is that the number of intra-zonal trips in NP increases to 24.4 percent from 13 percent and the zone is about balanced in terms of household demand and supply. This may be attributed to the higher travel times to the north Metro zones and to a lesser extent the eastern places are not so attractive, and the employment/housing ratio within the NP and NTIA zones has decreased slightly. Also, NP has increased in population from 20,000 to 105,000 and therefore is inherently more attractive. Self-containment is very high at 82 percent if the NP and NTIA zones are considered as a single zone. The general direction of the household seeking trips from NP and NTIA is similar to that in 1986, although a significantly smaller percentage locate in Metro Toronto because the number of unoccupied households has decreased. The percentage of people working at NTIA and living in NP increases from 19 percent (in 1986) to 47 percent (in 2001) for the reasons outlined above.

CONSTRAINED AGGREGATED SCENARIOS

Run No. 2

General Comments

When the housing location choice is contrained, the amount by which a zone is over-allocated (as shown in runs 1 and 3) is re-distributed a number of times until housing demand and supply in each zone is approximately in equilibrium. In the constrained runs, all iterations of this household balancing procedure are shown in the computer outputs in terms of households. In this specific run, iteration 4 showed that the balancing is not entirely completed although in most zones the supply/demand ratio is within the range 0.95 to 1.05. Those zones which were severely under-or-over-allocated initially had not converged.

The number of inter-zonal trips increases to 1,180,000 (run no. 2) from 1,050,000 (run no. 1) out of a total daily trip of 1,700,000 because of the re-distribution of demand. The mean trip time also increases from about 27 to 28 minutes. That is, employees in general are forced to locate in places which are slightly further from their workplaces.

Comments on NP and NTIA

The degree of self-containment of NP remains as in the unconstrained analyses at 13 percent (intra-zonal trips). However, considering NP and NTIA as one zone, the percentage of intra-zonal trips decreases to 68 percent from 73 percent. The household opportunities created as a result are partly filled by increased commuting from Toronto and

the eastern zones. The households in the north Metro zones accommodate a large portion of the over-allocation in the employment zones and thus become less attractive to NP workers. This is not so much the case for Oshawa-Whitby where the original distribution is almost in equilibrium. The filling of the north Metro zones has two effects. Firstly, it creates household competition in the zone and forces more people to live in NP (which in its own right is more attractive). Secondly, less people working in NP and NTIA will locate in Toronto (59 to 50 percent and 54 to 42 percent, respectively). The equivalent percentages for the eastern zones are 25 to 23 percent and 20 to 19 percent indicating little change. More NTIA employees are located in NP in the constrained run and most of the households are filled.

Run No. 4

General Comments

Compared with the constrained 2001 alternative (run no. 3) mean trip length of 28.26 minutes the mean trip time in this run is 29.04 minutes. The number of inter-zonal trips as a percentage of the total is about the same in the unconstrained and constrained runs (1,250,000), although in the latter run the trips are on the average longer in both time and distance.

Comments on NP and NTIA

As previously noted in the unconstrained run (no. 3) the household demand to supply in NP is almost in equilibrium. Therefore, the various commuting patterns from and to NP and from NTIA remain basically unchanged. The re-allocations in the other zones do not substantially change the commuting characteristics of these two zones.

CONSTRAINED DISAGGREGATED RUNS

Run No. 5

General Comments

The results of run no. 5 can be interpreted in relation to the results of run no. 2 since the input data is the same. The distributions differ, of course, since in run no. 5, the employment and housing opportunities are disaggregated and each income group is distributed according to a network made up of the car and transit skim trees.

The most significant change between the runs is that the number of inter-zonal trips is very significantly decreased in run no. 5 (85,000)

from run no. 2 (118,000) out of a total of 1,700,000. Therefore, the disaggregated regional self-containment is high at 50 percent, while the aggregated model results in 31 percent self-containment. The general changes between the runs may be explained by analysing the reasons for the above result. In general, there are two basic factors: firstly, the household choice is constrained to a degree in run no. 5 by the income-housing type probability matrix. Secondly, the work-to-home trip is now influenced differently for each income group by the transit travel times. These factors tend to act in opposite ways. The low income group is distributed entirely according to the transit times. This severely restricts inter-zonal travel since inter-zonal travel times are at least 1.3 as large as the car times, while for intra-zonal trips transit times are equal to the car times, and in the Toronto and Hamilton CBDs transit times are 80 percent of the car times. Thus, if a zone has enough housing opportunities associated with the low income group, then it is unlikely that inter-zonal trips will be made. Also, this income group may fill the higher income households associated with it rather than make the inter-zonal trip. The medium income group is distributed according to a time matrix which is an equally weighted combination of the transit and car skim tree travel times. Thus, the significant advantage in time of intra to inter-zonal trips is not present for the medium income group and a smaller percentage of intra-zonal trips result. This trend is shown in a further decrease in the percentage of intra-zonal trips made by the high income group since they locate according to travel times weighted 80 percent of the car time and 20 percent of the transit travel time.

The percentage of intra-zonal trips to the total number of trips within each income are 80 percent, 44 percent and 36 percent for the low, medium and high groups, respectively. The average percentage, as previously noted is 50 percent. This trend is logical but the percentages may be high in absolute terms. However, within the assumptions of the model, the figures seem reasonable.

The spatial distribution of employment and housing types, of course, effects the degree of self-containment. If a zone offers a majority of low income employment and yet contains only low density housing, then the percentage of inter-zonal trips would increase. However, the employment/housing ratio by income group and zone are fairly compatible and therefore this factor does not influence inter-zonal trip making greatly.

The total mean trip lengths are approximately equal in each run (27.86 and 28.13 minutes for runs numbers 2 and 5, respectively). Although, there are less inter-zonal trips in the latter case they are generally longer (transit times larger than car) and these two factors tend to balance each other.

Comments on NP and NTIA

The increase in self-containment (as measured by the intra to total trip ratio) is not as significant in North Pickering. However, the percentage of intra-trips does increase to 17 percent from 13 percent (runs no. 5 and 2, respectively) which to some extent reflects the introduction of the transit skim trees as outlined above. If NP and NTIA are considered as one zone, then self-containment is increased to about 80 percent from 68 percent. The direction of household locations of those working in NP and NTIA is similar in proportion to those in run no. 2, although the percentages are generally lower since there are more intra-zonal trips. Also, the general commuting patterns to NP from Toronto and the east found in run no. 2 are similar to those obtained in this run.

The relatively small percentage of intra-zonal trips in NP is due to the fact that the airport employment displaces many of the NP workers, especially in the lower income group. The 80 percent self-containment resulting from the aggregation of NP and NTIA is higher than the regional average of 50 percent because the communities are fairly isolated. The compositions of the various percentages noted here are shown in the next section.

RUN NO. 6

General Comments

Run no. 6 differs from run no. 5 in that the population of NP is 60,000 and the housing and employment opportunities are increased to reflect this. The airport employment remains at 60,000. When viewed from a regional point of view the change is almost insignificant and the comments concerning run no. 5 are applicable.

Comments on NP and NTIA

First, at an aggregated level, the employment/household ratio is decreased since the employment at the airport remains constant. The most significant feature is that the self-containment of NP alone increases to 28.6 percent (run no.6) from 16.6 percent (run no. 7). This reflects the fact that the larger an urban place the more self-contained it will be if all other factors remain constant. In fact, the number of trips from NTIA to NP as a percentage of the total NTIA employment increases from 28 percent to 50 percent. As a consequence of this, the percentage of trips from NP and NTIA to Toronto and the east decrease, although they are in the same proportion as in run no. 5.

The aggregated and income specific percentage of intra-zonal trips for NP and NTIA are shown in Figure D.1 for runs no. 5 and 6. The increase

FIGURE D.1 — PERCENT OF INTRA-ZONAL TO TOTAL TRIPS

in self-containment discussed above is illustrated. The figure also shows that the percentage of intra-zonal trips for all income groups increase proportionally from run no. 5 to run no. 6. Since all other zonal characteristics and travel behaviour remain constant, the increase is due to the expansion of the NP population from 25,000 to 60,000. Note that the low income group is more self-contained for the previously outlined reasons (i.e., transit times tend to discourage severely inter-zonal trips). The amount of self-containment is very high if the NTIA is considered with NP and in sum the percentage of commuting outside of the area increases with higher income.

RUNS NOS. 7 AND 9

General Comments

Run no. 7 is the disaggregated version of run no. 4. The employment in NP is reduced from 46,000 (no. 7) to 40,000 (no. 6) and on a regional scale this is insignificant. The trends generated between the disaggregated and aggregated 1986 runs (run nos. 5 and 2, respectively) are also shown here and similar explanations are applicable. The number of inter-zonal trips decreases from 122,000 to 949,000; that is, from 56 percent (no. 4) to 43 percent (no. 7). The total number of daily work-to-home trips in this run is approximately 2,200,000. The mean trip length for the disaggregated case is 28.12 minutes (from 29.04 for run no. 2) and the drop in the number of inter-zonal trips, in combination with the introduction of the transit times act to produce this.

Run no. 9 assumes an alternative NP population of 90,000 and may be compared to run no. 7 (pop. of NP = 105,000). At the regional scale, the properties of runs no. 9 and no. 7 are very similar (i.e., percentage of inter-zonal trips is 43 percent and the mean trip time is 28.15 minutes).

Comments on NP and NTIA

Since the increase in population of 90,000 to 105,000 is not particularly significant, the disaggregated run only increases the percentage of intra-zonal trips in NP to 25 percent (run no. 7) from 23 percent (run no. 4). The reasons for this fairly small increase are two-fold. Firstly, the threshold in terms of the size of the place has been exceeded and secondly, the employment housing ratio is increased slightly (since employment opportunities decrease by 6,000) which would tend to generate more commuting. These factors tend to offset each other.

In general, the commuting patterns from and to NP and NTIA remain the same. Twice as many trips originate in the eastern zones as opposed to Toronto (4 percent and 8 percent respectively), and twice as many

of the trips originating in NP and NTIA (40 percent and 20 percent from NP and 29 percent and 15 percent from NTIA) are destined to Toronto as opposed to the eastern zones. The housing availability of each of these areas determines the general direction of flows as outlined previously.

When comparing run no. 7 and no. 9 at the sub-regional scale it should be noted that the employment in NP for run no. 7 is 40,000 while in the latter is 34,500. The minor changes in the percentages between the two runs may be explained in terms of this difference in population. The percentage of trips from NTIA to NP decreases from 44 percent to 38 percent since there are less housing opportunities present in NP. However, on an income basis the percentage of intra-zonal trips in the low income group is again higher than for the other two incomes. Figure D.2 illustrates these results. The figure shows that there is little change in the commuting patterns, even at the disaggregated level, between runs no. 9 and no. 7.

RUN NOS. 5, 10, AND 11; 6, 14 AND 15

Runs no. 10 and no. 11 are similar to run no. 5 except the housing policies change in the following ways:

no. 10 - 30/70 low to high density - more attractive to lower incomes
no. 5 - 50/50 low to high density - equally attractive
no. 11 - 70/30 low to high density - more attractive to higher incomes.

At a regional scale this has very little impact and the general comments concerning run no. 5 are applicable.

At the sub-regional scale, it should be noted that the number of households available in NP for run nos. 5, 10 and 11 change. This is due to the fact that the average household occupancy is different in each household density class. Thus, if zone populations are to remain constant then there will generally be less total households available if lower density housing predominates, and more if high density housing is in the majority.

Figure D.3 shows the percentage of household opportunities by income group in NP and also the employment opportunities by income group for NP and NP combined with NTIA. The latter percentages are the same for each run. It may be noted that there is only a minor change in the actual number of household opportunities available in each income group for each of the three alternatives. This is due to two conversion factors. Firstly, some households are associated with middle income earners and secondly, the regional low income household demands are modified to equal the regional low income household supply, and so on. If the income-household density matrix were made more severe but less realistic (for example, low income people only associated with high density housing instead of probabilities) then the initial household percentages by density would be reflected more in the final household percentages by income group.

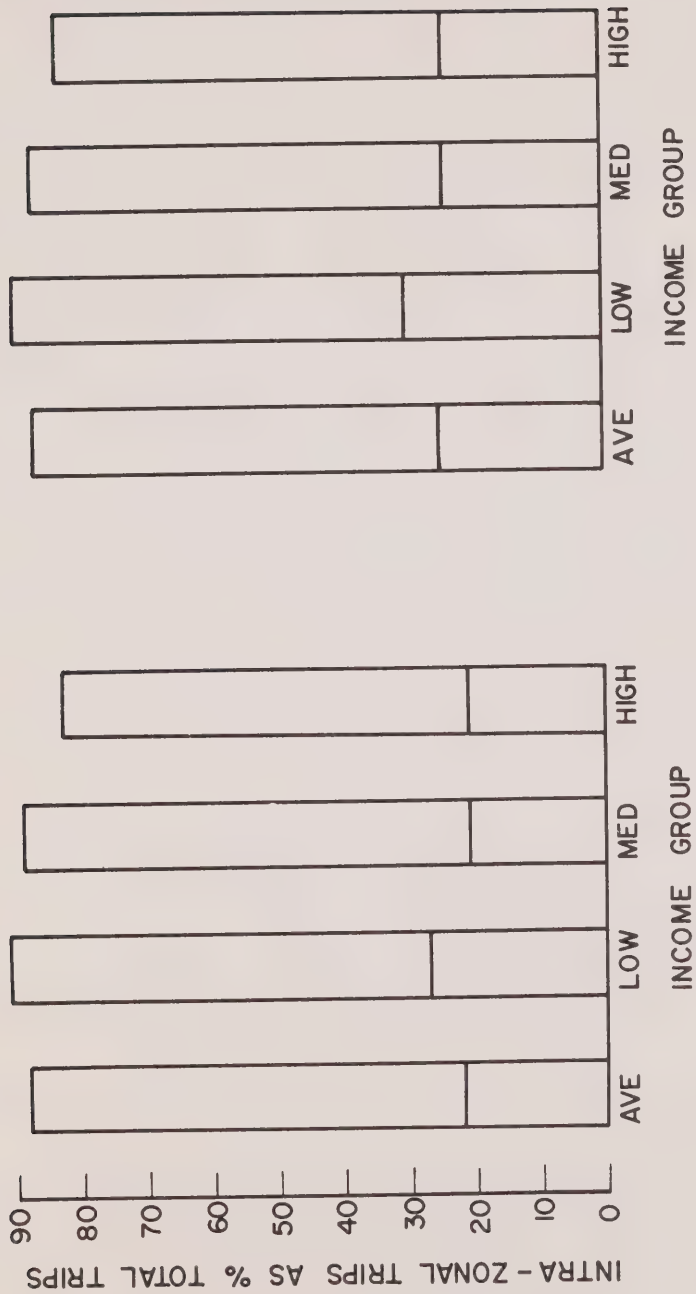


FIGURE D.2 – PERCENT OF INTRA-ZONAL TO TOTAL TRIPS

As shown on Figure D.3, the so-called low income oriented housing policy run (no. 10) has only 7 percent more low income associated households than run no. 11, the high income oriented housing policy run. It would be expected then that any change in commuting patterns would be relatively small.

It may also be noted from Figure D.3 that the percentage of employment opportunities in each income group (of the total opportunities) in NP and in NP and NTIA combined is consistent with the housing available for each income group. Thus, the degree of self-containment represented in runs 5, 10 and 11 is probably at a maximum.

Table 2 shows that the percentage of intra-zonal trips decreases originally from 17 percent to about 16 percent for runs no. 10 and 11, respectively. These represent the low and high income oriented housing policies respectively (as shown in Figure D.3). This change in percentage is extremely small because of the reasons outlined above (i.e., change in actual housing opportunities is very slight). However, it does agree with the previously noted and explained behaviour that the lower income group tends to make less commuting trips. The percentage of trips from NTIA to NP decreases. Since a large percentage of the NP low income workers locate in NP, the number of low income housing opportunities decreases and it may force some of the NTIA workers to locate elsewhere.

The other percentages are similar to run no. 5 which has been discussed previously.

Run nos. 6, 14 and 15 assume a NP population of 60,000 and the housing and work opportunities in the zone are both 19,000. In general, the level of self-containment is greater in these runs as opposed to those indicated by run nos. 5, 10 and 11 because of the increase in the size of NP. The change in the percentage of intra-zonal trips reinforces the above comments. That is, if a greater majority of low income housing is supplied then a greater percentage of intra-zonal trips results. The other percentages are similar to those discussed above.

RUN NOS. 7, 12 AND 13

These runs again illustrate the slight decrease in self-containment when the high income oriented housing policy is used. The changes in the other percentages are similar to those recorded between run nos. 5, 10 and 11 and run nos. 6, 14 and 15.

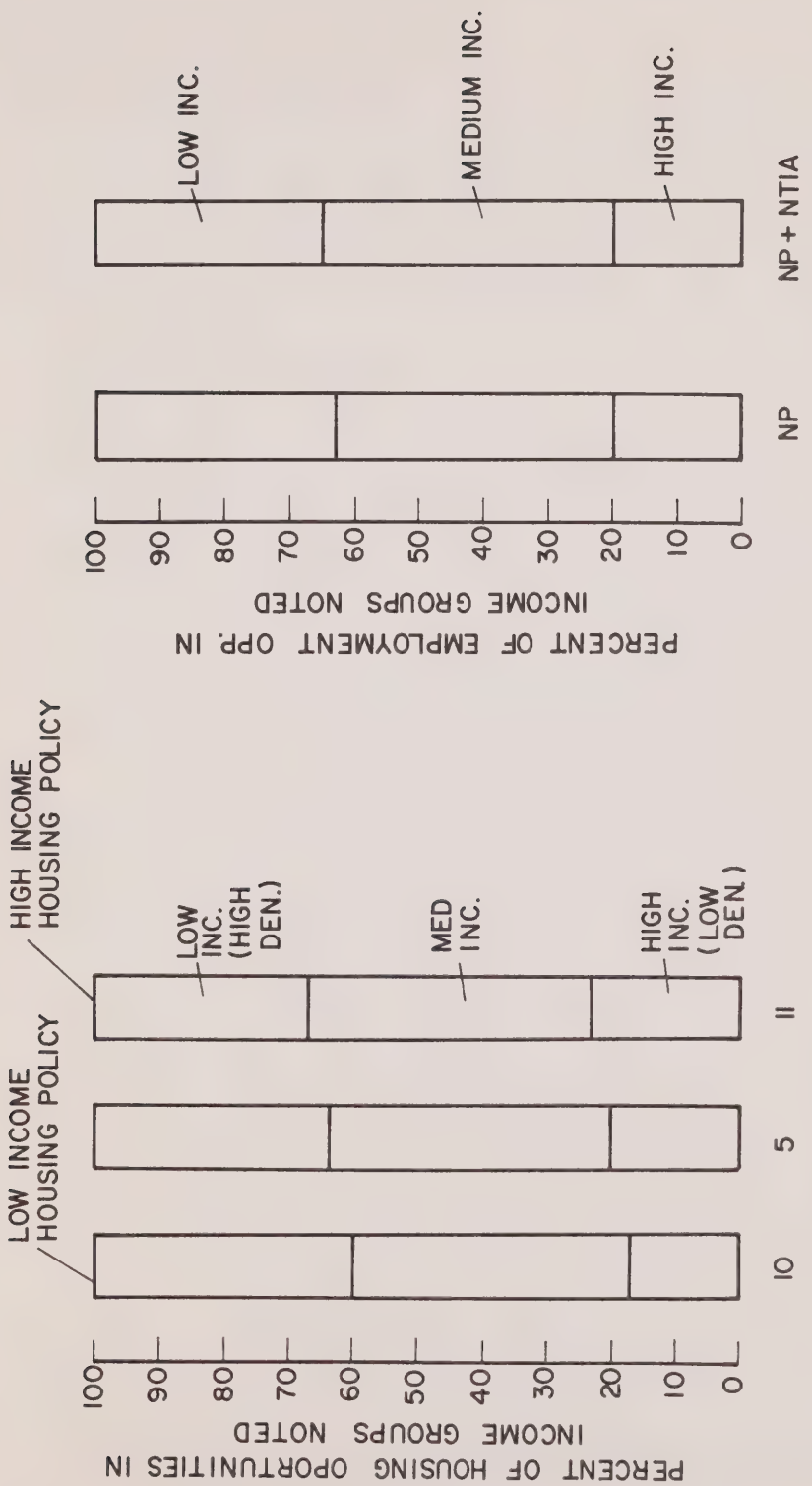


FIGURE D.3 – HOUSING AND EMPLOYMENT BY INCOME GROUP IN NORTH PICKERING

RUN NOS. 7 AND 8

If the NTIA does not exist, then the self-containment of NP considered alone increases significantly from 25 (run no. 7) to 61 percent (run no. 8). The employment/housing ratio for the NP and NTIA area is increased in the latter run and therefore competition for available households is not as intense. That is, the NTIA workers do not displace NP employees. The percentages of trips originating and destined to NP from outside places is decreased as a result of the above. However, the directional proportions remain the same.

RUN NOS. 1, 16 AND 2, 17

The most outstanding change on a regional basis is that the runs with the less restrictive travel time parameters (nos. 16 and 17) produce higher percentages of inter-zonal trips (81 and 85 percent as compared to 62 and 70 percent for run nos. 1 and 2). This indicates that the degree of self-containment is reduced in run no. 16 and 17, a result that would be anticipated. In these runs, the travellers are less sensitive to travel times and on the average will locate further from their workplace. The all-trip mean trip lengths, as a result are increased significantly to 32.62 and 32.87 from 27.14 and 27.96 minutes for run nos. 16, 17, 1 and 2, respectively.

The change in the degree of self-containment in NP reflects this. The intra-zonal percentage of trips (of the total attracted to NP) decreases to 5 percent in these runs compared to 13 percent in the initial runs. Similarly, the NTIA - NP work-to-home percentages decrease very significantly from approximately 60 percent to 20 percent since the workers sensitivity to travel time is decreased. If NP and NTIA are combined then the degree of self-containment is about 25 percent a reduction from 70 percent (runs 1 and 2). Fifty-five percent (55%) of the NP households are now filled by people working in Toronto. This is much higher than the 8 percent in runs 1 and 2 since in NP is now in commuting distance of the major employment zones (18, 20 and 21) in north Toronto. For example, in run no. 1 only 22 trips from zone 18 are destined to households in NP because of the high sensitivity to travel time. In run no. 16 this figure is increased to 1,246 which itself accounts for nearly 16 percent of the total trips attracted to NP. On the other hand, the percentage of trips to NP (home end) from the eastern zones (work end) remain constant since there is a fairly equitable employment/housing ratio in these areas. Of the additional trips leaving NP most go to Metro to occupy households which are made available by the increased commuting from Toronto. A slightly smaller percentage of the NP employees locate to the east. Similar changes occur in the NTIA work to home trips as for the NP zone. It should be noted that the sum of the percentages of trips originating in the NTIA and destined to NP, Toronto and the east is 93 percent in run no. 1, it is about 90 percent in run no. 6. The trips represented by the 3 percent difference must go to zones external to those considered such as those north and west

of Metro Toronto.

RUN NOS. 3, 18 AND 4, 19

The self-containment of NP in runs no. 18 and 19 are higher than those for runs no. 16 and 17 (about 14 and 5 percent, respectively). This has already been noted and is due to the increase in the NP population from 25,000 to 105,000 which makes the community inherently more attractive as a residential place. However, as noted above, the basic difference between run no. 18 and no. 19 and run no. 3 and no. 4 in NP alone and the NP and NTIA combined is that they are less self-contained. Also, the changes noted above concerning the other percentages as listed on Tables 2 and 3 are similar in this run. The mean trip lengths are higher at 32.73 and 33.08 minutes (runs no. 18 and 19) than for any other runs since employees are less sensitive to travel time and the skim tree times are larger.

Ministry of
Housing
Hon. Donald R. Irvine, *Minister*
R. M. Warren, *Deputy Minister*